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REPORT

ON

GEORGETOWN LAKE

DEER LODGE AND GRANITE COUNTIES

MONTANA

EPA REGION VIII

WORKING PAPER NO. 795

WITH THE COOPERATION OF THE

MONTANA DEPARTMENT OF HEALTH & ENVIRONMENTAL SCIENCES

AND THE

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MAY, 1977

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

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CONTENTS

	Page
Foreword	ii
List of Montana Lakes and Reservoirs	iv
Lake and Drainage Area Map	v
Sections	
I. Conclusions	1
II. Lake and Drainage Basin Characteristics	3
III. Lake Water Quality Summary	4
IV. Nutrient Loadings	8
V. Literature Reviewed	12
VI. Appendices	13

FOREWORD

The National Eutrophication Survey was initiated in 1971 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGEMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U.S. Environmental Protection Agency) express sincere appreciation to the Montana Department of Health and Environmental Sciences for professional involvement, to the Montana National Guard for conducting the tributary sampling phase of the Survey, and to those Montana wastewater treatment plant operators who voluntarily provided effluent samples.

The staff of the Water Quality Bureau provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

Major General John J. Womack, the Adjutant General of Montana, and Project Officer Major William Yeager, who directed the volunteer efforts of the Montana National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY
STUDY LAKES AND RESERVOIRS
STATE OF MONTANA

LAKE NAME	COUNTY
Canyon Ferry	Broadwater, Lewis and Clark
Clark Canyon	Beaverhead
Flathead	Flathead, Lake
Georgetown	Deer Lodge, Granite
Hebgen	Gallatin
Koocanusa	Lincoln, MT; British Columbia, Can.
Mary Ronan	Lake
McDonald	Flathead
Nelson	Phillips
Seeley	Missoula
Swan	Lake
Tally	Flathead
Tiber	Liberty, Toole
Tongue River	Big Horn
Whitefish	Flathead
Yellowtail	Carbon, Bighorn, MT; Bighorn, WY

Mont.
Map Location
Georgetown
outlet
Silver Lake
outlet
GEORGETOWN LAKE
Tributary Sampling Site
Lake Sampling Site
Drainage Area Boundary
Km.
Mi.
Scale

GEORGETOWN LAKE

STORET NO. 3004

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Georgetown Lake is eutrophic. It ranked ninth in overall trophic quality when the 15 Montana lakes and reservoirs sampled in 1975 were compared using a combination of six parameters*. Eight of the water bodies had less and one had the same median total phosphorus, ten had less median dissolved orthophosphorus, none had less but four had the same median inorganic nitrogen, 12 had less mean chlorophyll a, and seven had greater mean Secchi disc transparency. Some depression of dissolved oxygen with depth occurred at stations 1 and 3 in July.

The Montana Department of Fish and Game reports that extensive growths of aquatic vegetation occur in the lake (Whitney, 1972). Fish kills occasionally occur due to oxygen depletion during periods of ice cover (Ketelle and Uttormark, 1971).

B. Rate-Limiting Nutrient:

The algal assay results indicate that Georgetown Lake was nitrogen limited at the time the sample was collected (07/29/75).

The lake data indicate nitrogen limitation at all three stations in July and at two of the three stations in September.

* See Appendix A.

C. Nutrient Controllability:

1. Point sources--No known municipal or industrial wastewater treatment plants impacted Georgetown Lake during the sampling year.

Septic tanks serving lakeshore dwellings, camps, and a park are estimated to have added 7% of the measurable phosphorus load to the lake, but a shoreline survey would be necessary to determine the actual contributions of those sources. However, in terms of fishing pressure per hectare, Georgetown Lake is the most heavily used of all Montana lakes (Whitney, op. cit.), and septic tank loads may be of greater significance than is estimated.

During the sampling year, the phosphorus loading to the lake from measurable sources amounted to only 18% of that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 11). However, the trophic condition of the lake indicates the actual loading probably is at or near a eutrophic loading (i.e., about 4,250 kg/yr). If so, the load contributed by the submarine springs must be substantial.

2. Non-point sources--It is estimated that non-point sources contributed 93% of the measurable phosphorus load during the sampling year. The North Fork of Flint Creek contributed about 12%, and the ungaged minor tributaries and immediate drainage contributed an estimated 55.8%. However, as noted above, the submarine springs probably are the most significant non-point source.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Morphometry††:

1. Surface area: 11.20 kilometers².
2. Mean depth: 3.4 meters.
3. Maximum depth: 11.6 meters.
4. Volume: 38.288 x 10^6 m^3.
5. Mean hydraulic retention time: 342 days.

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)†††	Mean flow (m^3/sec)†††
North Fork Flint Creek	37.3	0.144
Submarine springs*	-	0.493
Minor tributaries & immediate drainage -	88.8	0.660
Totals	126.1	1.297

2. Outlets -

Anaconda Aqueduct	-	0.527
Flint Creek	137.3	0.770
Totals	137.3**	1.297

C. Precipitation***:

1. Year of sampling: 62.0 centimeters.
2. Mean annual: 38.3 centimeters.

† Table of metric conversions--Appendix B.
†† Norpestad, 1975.
††† For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
* Submarine spring flow accounts for difference between surface inflow and outflow (Knight et al., 1976).
** Includes area of lake.
*** See Working Paper No. 175.

III. WATER QUALITY SUMMARY

Georgetown Lake was sampled two times during the open-water season of 1975 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at three stations on the lake (see map, page v). During each visit, a single depth-integrated (4.6 m or near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and in July, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 9.4 meters at station 1, 5.5 meters at station 2, and 4.6 meters at station 3.

The sampling results are presented in full in Appendix D and are summarized in the following table.

[redacted]

B. Biological Characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
07/29/75	1. Fragilaria sp.	732
	2. Oocystis sp.	620
	3. Cryptomonas sp.	304
	4. Flagellates	304
	5. Tetraedron sp.	314
	Other genera	174
	Total	2,616
09/04/75	1. Chroomonas sp.	641
	2. Fragilaria sp.	629
	3. Oscillatoria sp.	66
	4. Anabaena sp.	66
	5. Microcystis sp.	66
	Other genera	110
	Total	1,476

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
07/29/75	1	4.2
	2	3.6
	3	10.4
09/04/75	1	6.8
	2	4.6
	3	12.3

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l - dry wt.)
Control	0.015	0.035	3.6
0.05 P	0.065	0.035	3.7
0.05 P + 1.0 N	0.065	1.035	23.1
1.0 N	0.015	1.035	7.8

V. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates the potential primary productivity of Georgetown Lake was moderately high at the time the sample was collected (07/29/75). Also, the lack of yield increase with the addition of phosphorus until nitrogen was also added indicates nitrogen limitation at that time. Note that the addition of nitrogen alone resulted in a yield significantly greater than that of the control.

The lake data indicate nitrogen limitation at all stations in July (the mean inorganic nitrogen/orthophosphorus ratios were 4/1 or less) and at stations 1 and 2 in September (the mean N/P ratios were 10/1 and 13/1, respectively); however, phosphorus limitation is indicated at station 3 in September (the mean N/P ratio was 20/1).

IV. NUTRIENT LOADINGS
(See Appendix F for data)

For the determination of nutrient loadings, the Montana National Guard collected monthly near-surface grab samples when possible from each of the tributary sites indicated on the map (page v), except for the high runoff month of June when two samples were collected. Sampling was begun in October, 1974, and was completed in September, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Montana District Office of the U.S. Geological Survey for the outlet and the North Fork Flint Creek.

In this report, nutrient loads for sampled tributaries were calculated using mean annual concentrations and mean annual flows. Nutrient loads for the Anaconda Aqueduct were calculated using the mean concentrations in the Flint Creek outlet (station A-1) and the monthly flows provided by the Anaconda Company.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the mean concentrations in the North Fork Flint Creek at station B-1 and the mean annual ZZ flow.

Nutrient loads were not estimated for the extensive submarine spring flows known to occur in the lake (Shields, 1976).

A. Waste Sources:

1. Known municipal - None
2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
North Fork Flint Creek	95	12.2
Submerine springs	"	"
b. Minor tributaries & immediate drainage (non-point load) -	435	55.8
c. Known municipal STP's - None	-	-
d. Septic tanks* -	55	7.0
e. Known industrial - None	-	-
f. Direct precipitation** -	195	25.0
Total	780	100.0

2. Outputs -

Lake outlet - Aqueduct	800
Flint Creek	730
Total	1,530

3. Net annual P accumulation - unknown; unmeasured load in spring flow.

* Estimate based on 141 lakeshore dwellings, eight camps, and one park; see Working Paper No. 175.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
North Fork Flint Creek	3,920	10.8
Submarine springs	?	?
b. Minor tributaries & immediate drainage (non-point load) -	17,960	49.8
c. Known municipal STP's - None	-	-
d. Septic tanks* -	2,125	5.9
e. Known industrial - None	-	-
f. Direct precipitation** -	12,090	33.5
Total	36,095	100.0

2. Outputs -

Lake outlet - Aqueduct	15,255	
Flint Creek	22,290	
Total	37,545	

3. Net annual N accumulation - unknown; unmeasured load in spring flow.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
North Fork Flint Creek	3	105

E. Mean Nutrient Concentrations in Ungaged Stream:

Tributary	Mean Total P Conc. (mg/l)	Mean Total N Conc. (mg/l)
Blodgett Gulch	0.097	0.823

* Estimate based on 143 lakeshore dwellings, eight camps, and one park; see Working Paper No. 175.
** See Working Paper No. 175.

F. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m²/yr	0.07*	?	3.2*	?

Vollenweider phosphorus loadings (g/m²/yr) based on mean depth and mean hydraulic retention time of Georgetown Lake:

"Dangerous" (eutrophic loading)	0.30
"Permissible" (oligotrophic loading)	0.19

* Measurable loading.

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VI. APPENDICES

APPENDIX A

LAKE RANKINGS

[illegible] LAKES LISTED TO BE USED IN [illegible]

LAKE CODE	LAKE NAME	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 0.107 x 10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

APPENDIX B

PHYSICAL and CHEMICAL DATA

[illegible]

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APPENDIX E

TRIBUTARY DATA

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